HILGARDIA

A JOURNAL OF AGRICULTURAL SCIENCE

PUBLISHED BY THE

CALIFORNIA AGRICULTURAL EXPERIMENT STATION

VOL. 1 NOVEMBER, 1925 No. 9

SECONDARY SEX CHARACTERS IN ASPARAGUS OFFICINALIS L.

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INTRODUCTION

Common asparagus is normally dioecious. Casual observations in the field reveal no striking differences between the two sexes in their vegetative characters. Careful studies, however, show that there are significant quantitative differences between staminate and pistillate individuals.

Secondary sex characters in plants are far less striking than they are in animals. It is probably for this reason that they have received so little attention.

Cowles[1] calls attention to the fact that "immediately after flowering it often is possible to distinguish at some distance pistillate from staminate mulberry trees by their much smaller leaves, as though the constructive material in the former were utilized chiefly in fruit development, and in the latter, in leaf development." Later in the season, the leaves are equally large on both pistillate and staminate individuals.

Guinier[3] states that dioecism in the case of *Pinus montana* and *P. sylvestris* is accompanied by a certain vegetative dimorphism. In purely staminate individuals, the branches terminating in inflorescences have the cones distributed over the greater part of the new shoots, a relatively small area being left at the apex for the short, leaf-bearing twigs. After these male cones have fallen, there is left a long bare section at the base of each new shoot, the leaves forming a tuft at the tip of the shoot. In purely pistillate individuals, the

branches terminating in inflorescences are almost entirely covered with leaves. It is stated further that in *Pinus montana,* subsp. *uncinata* (in the Pyrenees), the staminate individuals, when compared

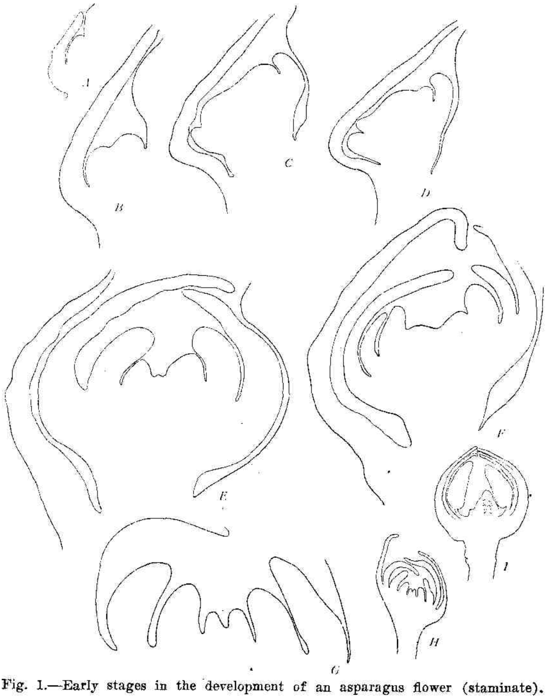


Fig. 1.—Early stages in the development of an asparagus flower (staminate).

with pistillate, are seen to have wider spreading, somewhat intertwined, branches, less abundant foliage and a more irregular and spreading crown.

Hemp (*Cannabis sativa* L.) is dimorphic in its vegetative as well as its floral characters. McPhee[4] describes the differences between male and female individuals as follows:

"Staminate plants: More slender and taller than carpellate plants because of the rapid elongation of the internodes just prior to anthesis; terminal inflorescences with practically no leaves; flowers normally with five sepals and as many anthers; much shorter life than the carpellate type.

Carpellate plants: More vigorous but shorter than the staminate type; terminal inflorescence leafy; broad crown of leaves; flowers with perianth but no vestige of stamens; weight at maturity about twice that of the staminate type; longer life."

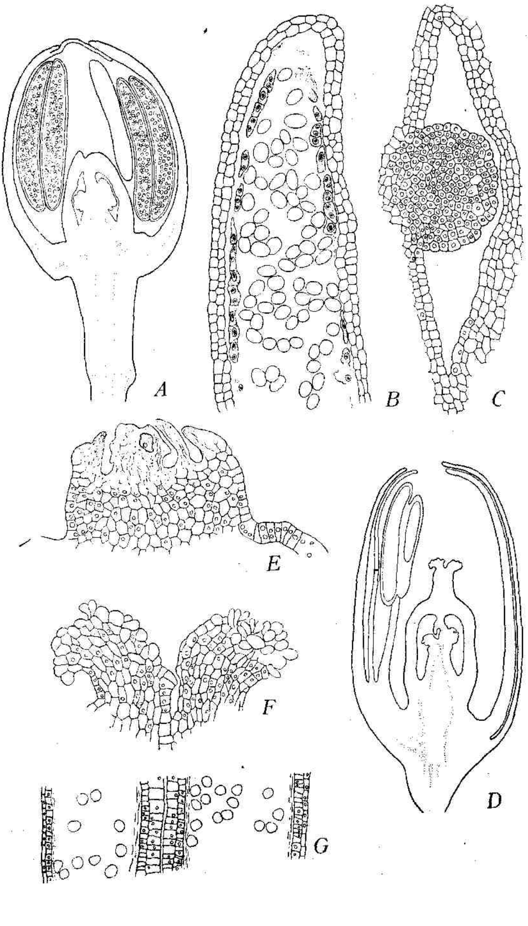
Rosa[6] finds that the male spinach plants send up their seed stems and bloom from one to two weaks earlier than the female. The male plants die from two to four weeks after the beginning of anthesis while the female plants continue blooming for a period of eight weeks or more.

In *Merculialis annua* L., according to Yampolsky,[9] "the female inflorescences are borne in clusters in the axils of the leaves, while the male inflorescences are borne in interrupted spikes which surpass the leaves."

Floral Development.—It is not our purpose here to describe fully the floral development in asparagus. A brief statement will suffice to make clear the bearing it has on the main subject matter of this paper.

The first evidence of the flower is a slight rounded protuberance in the axil of a scale leaf (fig. 1, A). This broadens and becomes slightly elevated at the rim. The primordia of the outer perianth segments are the first to appear; these are followed in turn by the primordia of the inner whorl of perianth segments, the outer whorl of stamens, the inner whorl of stamens, and last by the carpels. The stages in the development of a staminate flower are shown in fig. 1. The early stages of development of staminate and pistillate flowers are indistinguishable.

Fig. 2.—Developmental stages of two different staminate flowers (A, B, and C) and (D, E. F, and G), showing abortion of pistil. A, median lengthwise section of staminate flower; B, portion of single locule of anther, showing wall cells, disintegrating tapetal cells, and pollen grains; C, ovule of flower shown in A and B; note that in this particular flower, the megaspore mother cell had not become differentiated in the nucellus, although pollen grains are mature; D, median lengthwise section of another staminate flower; E, in this flower, the megaspore mother cell had become differentiated by the time the pollen grains were mature, but the surrounding nucellar tissue and integuments showed disintegration; F, stigma of same flower; G, section of anther.


A
B
C
E
D
F
G

In young staminate flowers, the rudimentary pistil may have a shape typical of that of pistillate flowers of the same age, but it fails

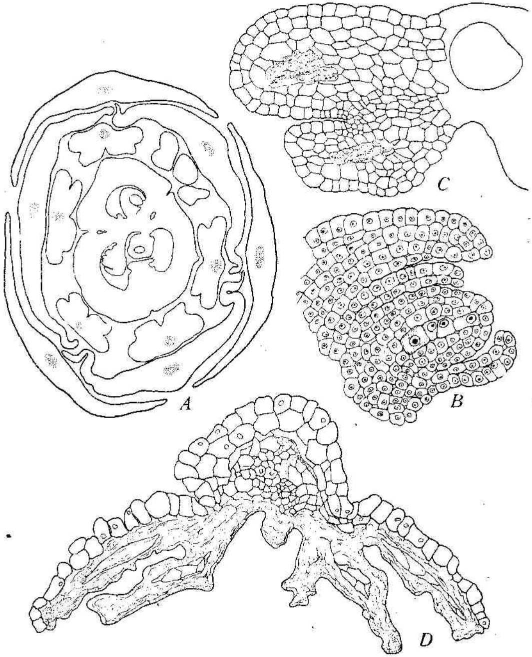


Fig. 3.—Developmental stages of pistillate flower, showing abortion of stamens. A, floral diagram of pistillate flower, the ovules of which have progressed to stage shown in B, and the anthers of which have begun to manifest disorganization of sporogenous cells. As the flower matures, disorganization of anther tissue proceeds, finally attaining the condition shown in D.

to attain normal size. The absence or very weak development of the style and stigma is characteristic of staminate flowers; it may have locules in the ovary, and ovules may begin development, but they fail to reach maturity. The ovule of the staminate flowers seldom

develops further than the primary archesporial stage; the integuments seldom attain a size sufficient to enclose the ovule. Disorganization of the ovule begins before the anther of the same flower has reached maturity (fig. 2). Young pistillate flowers may develop for a time stamens similar to those of the purely staminate flowers, but the anthers do not attain normal size, the filaments are short, and the immature pollen mother cells disintegrate. Shortly after, the entire anther shrivels (fig. 3).

It will thus be observed that all asparagus flowers in the primordial stages bear both sets of sex organs, and hence are apparently potentially hermaphroditic. During their subsequent development there is, except in rare cases, an abortion of either the male or female sex organs. The degree of abortion varies. There is no evidence of transmutation of pistils into stamens and of stamens into pistils.

Sex Intergrades.—Sex intergrades occur in a great many plants (Yampolsky[9]) among which should be included *Asparagus officinalis.* Normal male flowers bear six well-developed stamens and a single rudimentary pistil (fig. 4). Normal pistillate flowers have a single well-developed pistil and six rudimentary stamens (fig. 4). Occasionally, hermaphroditic flowers are found. Our observations show that hermaphroditism in asparagus is very rare, at least under Californian conditions, and is limited to a relatively few flowers on plants that are predominately staminate (fig. 5).

Regarding asparagus, Norton[6] states: "Hermaphrodite plants occur now and then, but so far in our experiments can not be considered a factor in seed production. In flowers of the typical female plant, the rudiments of stamens exist, but the writer has never seen one developed sufficiently to even suggest the possibility of self-pollination. On the other hand, the male plants often show a well-developed ovary with style and stigma and sometimes even a typical stigmatic surface. The great majority of male flowers, however, lack a well-developed ovary, the rudiments being about half the size of the normal ovary of the female flower and lacking any stigmatic development, the style often being completely abortive. The hermaphrodite plants mentioned above are always of the male type, the flowers being for the greater part pure male in that they lack the complete and functionary ovary. In one wild plant examined the flowers at the extremities of the branches were typically female with well-developed stigma and abortive anthers. Another hermaphrodite plant which produced seed that would germinate and make healthy, vigorous plants had many flowers whose ovaries lacked the stigmas. The berries on these hermaphrodite plants are very small and rarely have more than one seed in

them. The seeds are usually peculiar in that the seed coats are not entirely developed. The seeds appear mottled black and white, varying from the white of the uncovered endosperm in the smaller seeds to

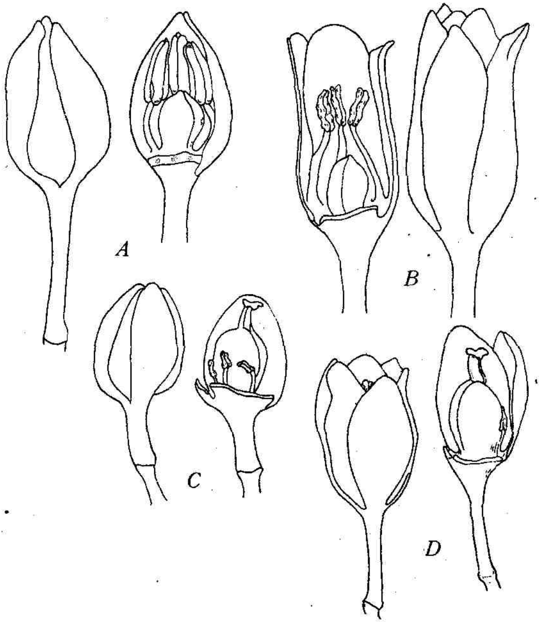


Fig. 4.—Strongly staminate and strongly pistillate flowers in external view, and with a part of the perianth segments removed. A, strongly staminate flower before anthesis; B, the same, after dehiscence of anthers; C, strongly pistillate flower, before anthesis; D, the same, when the stigma is receptive.

well-covered, entirely black seeds in which the coats have had their normal development and have completely covered the endosperm. These small seeds make weak plants and in many cases abnormal ones, but the larger, better developed seeds make healthy seedlings of normal type."

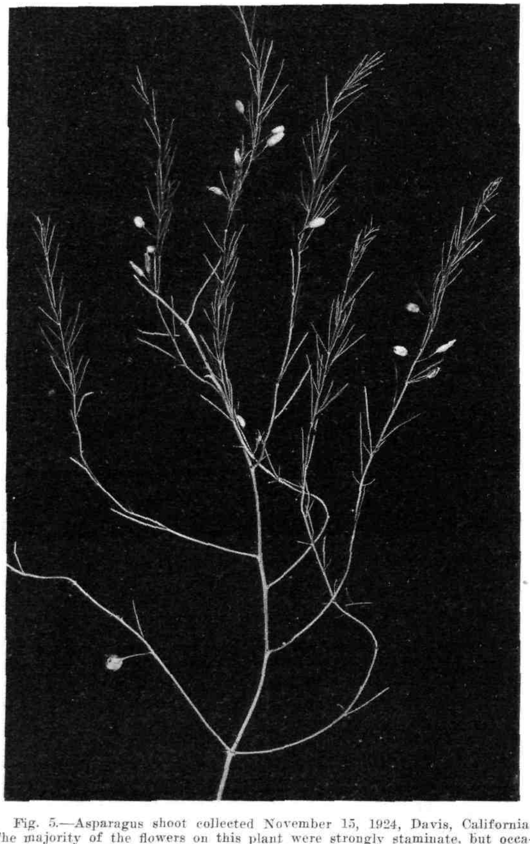


Fig. 5.—Asparagus shoot collected November 15, 1924, Davis, California. The majority of the flowers on this plant were strongly staminate, but occasionally toward the base of the shoots, a few hermaphroditic flowers occurred. Observe the single berry.

The following forms of individual flowers in asparagus have been observed: (1) strongly pistillate, (2) weakly pistillate, (3) hermaphroditic, (4) weakly staminate, and (5) strongly staminate. In "strongly pistillate" flowers, the ovary is well developed, the style is long, and the stigmatic surface plainly visible; whereas, the stamens are represented by the merest traces of atrophied tissue (fig. 4). In "weakly pistillate" flowers, the ovary is somewhat smaller than in the preceding case, but ovule-bearing, the style is short, the stigmatic surface is not so well defined, and the form of the anthers may be observed, although no pollen is produced, and the anthers soon wither. In true hermaphroditic flowers, both pollen-bearing anthers and ovule-bearing pistils are developed. Only a very small percentage of true hermaphroditic flowers have been observed among the hundreds of flowers examined in Californian asparagus fields. In "weakly staminate" flowers the stamens are short, but functional, and the ovaries are quite large and bear a short style but no ovules. In "strongly staminate flowers the stamens are well developed and normal in size, the pollen grains are functional, and the only evidence of the pistil is a very small conical body, without a style, in the center of the flower (fig. 4).

It has been observed that the same plant may bear both strongly and weakly pistillate flowers, or strongly and weakly staminate flowers.

Sex Ratio in the Fields.—The ratio of staminate and pistillate plants in commercial fields is shown in the accompanying table. This ratio was determined by walking down the asparagus rows and recording the sex of each plant.

TABLE 1

RATIO OF STAMINATE AND PISTILLATE PLANTS IN THE FIELD

Ranch	Location	Bed set	Date counted	Number of plants observed	Per cent staminate	Per cent pistillate	Per cent plants not in bloom
Cal. Packing Corp.	Ryer Island	1921	5/5/23	97	50.5	48.4	1.1
Cave & Patterson	Holland Land Tract	1922	6/9/23	944	47.3	52.3	0.4
Montezuma Ranch	Collinsville	1921	7/6/23	137	51.8	48.2	0
R. J. Grahams	Walnut Grove	1922	8/9/23	233	50.2	49.8	0
Hamilton Bros.	Tyler Island	1921	9/8/23	185	48.7	51.3	0

The data show that in the commercial asparagus fields there are virtually equal numbers of staminate and pistillate individuals.

Expression of Sex of Seedling Plants.—In the eastern states asparagus plants seldom bloom until the second year from seed, but in California a large percentage of plants flower the first year.

In the asparagus nursery on the University Farm, Davis, California, the blooming or fruiting dates of many seedling plants were recorded. Seed was planted February 28 and March 8.

TABLE 2

TIME OF SEX EXPRESSION OF SEEDLING PLANTS

Variety	Number of plants observed	Sex	Plants in bloom or fruit (1923)—Dates										
			7/2	7/7	7/11	7/13	7/16	8/2	8/4	8/7	8/11	8/27	9/3
Palmetto..........	2400	S*	15	26	37	88	127	173	201	398	450	507	530
Palmetto..........	2400	P*	0	0	0	0	0	3	17	47	86	120	213

* S=staminate; P=pistillate.

The above table shows that there is a tendency for staminate plants to express their sex much earlier in life than pistillate plants. Many plants do not flower the first season, but of those that do, by far the larger percentage are staminate. The last counts in the field were made on September 3, and by this date in a total population of 2400 plants 743 or 31 per cent had expressed their sex. Before the plants were killed by frost many more came into bloom. When the crowns were dug during the following winter, 482 additional plants were bearing fruit, making a total of 695 pistillate plants out of 2400 which expressed their sex the first year. If half of the plants are pistillate then approximately 58 per cent of these bloomed the first season in the nursery. Many more staminate plants came into bloom after September, but it was difficult at the time the crowns were dug to identify them as only the pedicels of the flowers remained.

Comparison of Staminate and Pistillate Seedling Plants.—Each new shoot which arises on the crown during the first year from seed is usually larger than the preceding. The first four secondary shoots so far as observed were never flower-bearing, but in a few individuals, the fifth secondary shoot did produce flowers. In staminate plants, the first flower-bearing shoot varied from the 5th to the 11th (average, 7.2 for the 149 plants observed); in pistillate plants the first flower-bearing shoot varied from the 5th to the 14th (average 8.5 for the 80 plants observed). These data were taken from August 8 to 11 on the Palmetto variety. Thus it is seen the first flower-bearing shoot usually appears earlier in the life of the staminate than

in the pistillate plant. Measurements made on the above two groups of plants (149 staminate and 80 pistillate), show that the average height of the first flower-bearing shoot of staminate plants is 47.8 cms., while the average height of the first flower-bearing shoot of pistillate plants is 62.4 cms., a difference in height of 14.6 cms., in favor of the pistillate stalks.

Top Growth of Staminate and Pistillate Plants the Year Crowns Are Set (1924). The relative vigor of staminate and pistillate plants, as indicated by the top growth made by the plants the year the crowns are set, is shown in table 3.

TABLE 3

STAMINATE AND PISTILLATE PLANTS—COMPARATIVE TOP GROWTH THE FIRST YEAR (1924)*

STAMINATE PLANTS

Row No.	Number of crowns	Average number of stalks per plant		Average total height per crown (inches)	Average height per stalk (inches)	Total weight green tops (lbs.)	Average weight green tops per crown (lbs.)
		May 25	Nov. 8	May 25	May 25	Nov. 8	Nov. 8
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	116	2.5	10.5	84.5	33.8	112.00	.97
3	120	2.9	....	66.3	22.8	87.75	.73
5	121	2.9	....	74.9	25.8	84.75	.70
7	118	2.2	....	67.2	30.4	112.75	1.00
15	233	....	8.0	....	....	142.00	.61
17	154	....	9.7	....	....	122.00	.79
19	93	....	10.4	....	....	103.50	1.11
21	81	....	10.8	....	....	93.50	1.15
31	120	3.0	....	73.0	24.3	104.75	.87
33	119	2.9	....	62.3	21.5	88.75	.75
35	118	2.5	....	50.9	20.4	88.75	.75
37	116	2.5	....	74.1	29.6	101.25	.87
45	236	....	6.7	....	....	108.50	.48
47	156	....	8.6	....	....	121.50	.78
49	93	....	10.2	....	....	90.50	.97
51	79	....	8.8	....	....	66.00	.84
61	120	1.1	....	45.2	41.1	89.75	.74
63	117	1.7	....	44.3	26.1	82.75	.71
65	120	1.6	....	41.0	25.6	87.75	.73
67	118	2.1	....	63.7	30.4	101.25	.86
Average......		2.37 ±0.122	9.3 ±0.338	63.3 ±2.8	27.6 ±1.14	99.5 ±2.6	0.82 ±0.024

* Analysis of these data shows that the differences between staminate and pistillate plants as expressed in columns 3, 4, and 5 are significant, whereas those of columns 6, 7, and 8 are not significant.

TABLE 3—(*Continued*)

STAMINATE AND PISTILLATE PLANTS—COMPARATIVE TOP GROWTH THE FIRST YEAR (1924)*

PISTILLATE PLANTS

Row No.	Number of crowns	Average number of stalks per plant		Average total height per crown (inches)	Average height per stalk (inches)	Total weight green tops (lbs.)	Average weight green tops per crown (lbs.)
		May 25	Nov. 8	May 25	May 25	Nov. 8	Nov. 8
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2	118	2.3	....	62.0	26.9	86.75	.73
4	119	1.9	....	55.6	29.3	74.75	.63
6	119	2.6	....	70.5	27.7	73.75	.62
8	118	1.6	....	53.3	33.3	98.75	.84
16	235	....	4.3	....	....	143.00	.63
18	154	....	6.5	....	....	129.00	.84
20	95	....	6.8	....	....	89.00	.94
22	76	....	7.2	....	....	85.00	1.11
32	117	2.0	....	57.2	28.6	83.75	.71
34	120	1.7	....	51.3	30.2	78.75	.66
36	119	1.9	....	52.0	26.8	79.75	.67
38	116	1.7	....	55.5	32.6	71.75	.62
46	234	....	4.5	....	....	114.50	.48
48	153	....	6.2	....	....	136.50	.89
50	92	....	6.4	....	....	80.00	.87
52	78	....	7.3	....	....	76.00	.97
62	117	1.7	....	45.7	26.8	95.75	.82
64	115	1.6	....	43.5	27.2	86.75	.75
66	114	1.5	....	44.2	29.4	86.25	.76
68	108	1.7	....	52.8	30.5	101.25	.94
Average.....		1.88 ±0.062	6.15 ±0.002	53.6 ±1.43	29.1 ±0.66	93.50 ±3.2	.77 ±0.024

* Analysis of these data shows that the differences between staminate and pistillate plants as expressed in columns 3, 4, and 5 are significant, whereas those of columns 6, 7, and 8 are not significant.

Table 3 shows that during the first season staminate plants produce a greater number of stalks, and a greater total height of stalks to the crown, but that there is no significant difference between staminate and pistillate as to average height of the stalk, total green weight of tops or average green weight of tops. A large percentage of the weight of the pistillate plants is comprised in the berries; the weight of these was not determined separately. If the weight of berries is subtracted from the green weight of tops it appears that the food-manufacturing surface of staminate plants exceeds that of the pistillate. It is to be expected therefore that a greater quantity of reserved food would be stored in crowns of staminate than in those of pistillate plants, and that the yield of shoots the following season

TABLE 4

STAMINATE AND PISTILLATE PLANTS—COMPARATIVE TOP GROWTH THE SECOND YEAR (1925)*

STAMINATE PLANTS

Row No. (1)	Number of crowns (2)	Average number of stalks per plant (Oct. 10, 1925) (3)	Total weight of green tops (lbs.) (4)	Average weight of green tops per crown (lbs.) (5)
1	116	10.5	294	2.5
3	118	9.1	298	2.5
5	117	10.8	309	2.6
7	118	6.9	360	3.1
15	233	4.8	410	1.8
17	153	7.6	394	2.6
19	93	11.6	375	4.0
21	81	14.2	312	3.9
31	118	12.0	403	3.4
33	118	8.7	340	2.9
35	118	9.7	370	3.1
37	116	7.8	339	2.9
45	236	5.3	350	1.5
47	155	7.7	404	2.6
49	93	9.2	294	3.1
51	79	10.6	235	3.0
61	119	9.1	318	2.7
63	116	6.9	325	2.8
65	119	8.3	312	2.6
67	116	7.4	285	2.5
Average		8.9 ±1.57	336.4 ±28.2	2.8 ±0.36

PISTILLATE PLANTS

Row No. (1)	Number of crowns (2)	Average number of stalks per plant (3)	Total weight (4) With berries (a)	Total weight (4) Without berries (b)	Average weight per crown (5) With berries (a)	Average weight per crown (5) Without berries (b)
2	117	6.2	311	193	2.7	1.7
4	115	6.0	235	146	2.0	1.3
6	116	6.0	250	155	2.2	1.3
8	117	4.7	321	198	2.7	1.7
16	235	3.8	439	272	1.9	1.2
18	154	5.7	382	237	2.5	1.5
20	94	6.1	270	167	2.9	1.8
22	76	7.7	245	152	3.2	2.0
32	117	5.9	249	154	2.1	1.3
34	119	5.7	300	186	2.5	1.6
36	119	5.3	255	158	2.1	1.3
38	116	5.4	282	175	2.4	1.5
46	234	3.1	389	241	1.7	1.0
48	151	4.4	425	264	2.8	1.7
50	92	5.5	248	154	2.7	1.7
52	78	7.1	160	99	2.1	1.3
62	116	4.9	295	183	2.5	1.6
64	115	4.8	266	165	2.3	1.4
66	113	4.9	222	138	2.0	1.2
68	107	4.8	229	142	2.1	1.3
Average		5.4 ±0.68	288.7 ±47.8	178.9 ±29.6	2.4 ±0.28	1.5 ±0.18

* Analysis of these data shows that the differences shown in columns 4a and 5a are not significant but that all other differences are significant.

would be greater. Table 6 shows that staminate plants do out-yield the pistillate at least the first season.

Top Growth of Staminate and Pistillate Plants the Second Year After Crowns Are Set (1925).—In early October, 1925, the top growth from the same rows considered in 1924 was harvested. At this time, the leaves were beginning to show a slight tinge of yellow. The plants were cut about two or three inches above the ground line and weighed within a few minutes afterwards, so that the amount of water lost was negligible. As in 1924, the number of stalks produced by staminate plants exceeds that from pistillate plants (table 4). When the weight of berries is added to that of the green tissue, there is no significant difference between staminate and pistillate plants as to the green weight of the top growth. But, if the weight of berries is deducted from the total weight of the plants, and a comparison made of green tissue, it is seen that the amount of this tissue produced by staminate plants greatly exceeds that produced by pistillate. The figures given in column 4*b* of table 4, are based upon the weight of mature berries harvested from row 8, in which it was found that the berries constituted 32 per cent of the total weight of the plants. Approximately 50 per cent of the weight of berries was seed. The berries were picked off by hand, care being taken to avoid stripping the "needles" from the plant.

Yield of Spears from Staminate and Pistillate Plants.—Experiments by Green,[2] performed on a small scale, seem to show that the staminate asparagus plants out-yield the pistillate under conditions as they exist in Ohio. Results obtained by Green are given in the following table:

TABLE 5

PRODUCT FROM FIFTY PLANTS EACH, STAMINATE AND PISTILLATE

	Fifty staminate plants, ounces	Fifty pistillate plants, ounces
First period, ten days	37	21
Second period, ten days	104	68
Third period, ten days	266	164
Fourth period, ten days	203	154
Total for the season	610	407

The staminate plants yielded 50 per cent more than the pistillate plants during the season. The superiority of the staminate plants is greater during the early part of the cutting season than during the late. Green concluded that fruit production makes a greater demand for food than does the formation of stamens, and that it is

for this reason that staminate plants are able to produce a greater growth of spears than pistillate.

Tompson[7] reports experiments with the Washington strain of asparagus at the Market Garden Field Station, Lexington, Mass., which show that the staminate plants produce more spears, but

TABLE 6

COMPARISON OF YIELD OF STAMINATE AND PISTILLATE PLANTS (1925)

Row No.	Sex	Average weight per crown when planted (gms.)	Number of crowns	Harvested Feb. 25 to Mar. 9		Harvested Feb. 25 to April 1				
				Total number of spears	Total weight of spears (gms.)	Total weight of spears	Average number of spears per crown	Total weight of spears per row (gms.)	Average weight of spears per crown (gms.)	Average weight of a single spear (gms.)
1	S	231	116	9	154	335	2.88	5543	47.8	16.66
2	P	206	118	5	94	196	1.66	3510	29.7	18.61
5	S	229	121	23	356	311	2.56	5185	42.8	16.27
6	P	232	119	11	157	206	1.73	3631	30.5	18.04
7	S	....	118	23	607	336	3.02	8229	74.0	25.72
8	P	....	118	1	55	199	1.61	5863	49.7	29.43
15	S	231	233	57	1145	570	2.44	10447	44.7	18.32
16	P	242	235	20	412	340	1.49	7606	33.4	22.35
17	S	164	154	45	942	445	2.89	8540	55.2	19.14
18	P	222	154	11	277	323	2.10	6273	40.7	19.43
19	S	189	93	40	865	362	3.89	7591	81.5	20.98
20	P	194	95	7	180	187	1.97	4638	48.8	24.78
21	S	161	81	22	440	276	3.41	5440	67.1	19.67
22	P	230	76	14	397	196	2.58	4568	60.0	23.23
31	S	205	120	43	394	423	3.53	8281	68.8	19.56
32	P	185	117	32	653	279	2.38	5598	47.8	20.13
35	S	165	118	32	565	332	2.81	5928	50.3	17.85
36	P	188	119	14	255	214	1.80	4055	34.0	19.25
37	S	150	116	54	1255	399	3.44	7865	67.9	19.72
38	P	115	116	26	647	234	2.02	5205	44.9	22.22
47	S	191	156	44	880	464	2.97	9143	58.5	19.68
48	P	159	153	33	752	346	2.26	8358	54.7	24.12
49	S	134	93	32	690	366	3.93	7007	75.4	19.65
50	P	129	92	11	310	167	1.82	4206	45.7	25.18
51	S	59	79	19	422	202	2.56	4152	52.5	20.53
52	P	155	78	25	597	216	2.77	4942	63.4	22.87
61	S	153	120	43	775	320	2.66	5815	48.4	18.15
62	P	186	117	12	229	244	2.08	5129	43.8	20.99
65	S	177	120	43	800	305	2.54	5751	47.9	18.86
66	P	172	114	7	100	197	1.73	3878	34.0	19.75
67	S	185	118	52	962	386	3.27	7367	62.5	19.07
68	P	187	108	22	605	204	1.89	4838	44.8	23.66

*An analysis of these data, using Students Method, shows that the results here given are significant.

SUMMARY OF TABLE 6

	Staminate	Pistillate
Total number of crowns	1949.00	1922.00
Total number of spears harvested from Feb. 25 to Mar. 9	581.00	251.00
Average number of spears harvested per crown from Feb. 25 to Mar. 9	0.29	0.13
Ratio of number of spears harvested from Feb. 25 to Mar. 9	2.32	1.00
Total number of spears harvested for season Feb. 25 to Apr. 1	5832.00	3748.00
Average number of spears harvested per crown for season Feb. 25 to Apr. 1	3.00	1.95
Ratio of number of spears harvested for season Feb. 25 to Apr. 1	1.55	1.00
Total weight of spears harvested from Feb. 25 to Mar. 9 (gms.)	11752.00	5720.00
Average weight of spears harvested per crown from Feb. 25 to Mar. 9 (gms.)	6.02	2.98
Ratio of weight of spears harvested from Feb. 25 to Mar. 9 (gms.)	2.05	1.00
Total weight of spears harvested for season Feb. 25 to Apr. 1 (gms.)	112292.80	82297.60
Average weight of spears harvested per crown for season Feb. 25 to Apr. 1 (gms.)	58.00	43.00
Ratio of weight of spears harvested for season Feb. 25 to Apr. 1 (gms.)	1.34	1.00
Average weight of single spear	19.25	21.90

that the proportion of giant asparagus is much greater from the pistillate plants. This held consistently true throughout their whole population, which was something over 1000 plants.

In a later report on the same project, Tiedjens[8] states that "Staminate plants are higher producing by 25 per cent, and hold up better from year to year.—Pistillate plants produce a greater percentage of 'A' (large) spears."[9]

The data shown in table 6, and derived from experimental plots at the University Farm, Davis, California, bear out the conclusions of previous investigators that there are important differences in earliness of production, total yield, and size of spears between staminate and pistillate plants.

Production of Spears the First Cutting Season.—In 1923 a large number of pistillate and staminate plants were labeled in the nursery. The following winter the crowns were dug and the different sexes planted in separate rows in the permanent bed. The rows were 240 feet long and the distance between rows seven and one-half feet. The crowns were set from one to three feet apart in the different rows. Corresponding staminate and pistillate rows were placed side by side. The harvesting of spears began on February 25, 1925, and continued until April 1. The spears were not cut until they were seven inches or more above the ground. They were cut to a length of nine inches or more in the field. When a row was harvested the spears were trimmed to a uniform length of eight and one-half inches, then counted and weighed. Table 6 gives the number of plants per row, the average weight per crown at time of planting, and the yield of the staminate and pistillate rows for the early part of the harvesting period and also for the entire cutting season. Rows 7 and 8 are Mary Washington, 37, 38, 67 and 68 Washington, and the remainder Palmetto.

The data in table 6 shows that the staminate plants produced more spears and a greater weight of spears during the first cutting

TABLE 7

TOTAL NUMBER AND WEIGHT OF SPEARS HARVESTED EACH CUTTING DAY FROM ALL STAMINATE AND PISTILLATE PLANTS

	Staminate plants (1949)		Pistillate plants (1922)	
	Total number of spears	Total weight of spears gms.	Total number of spears	Total weight of spears gms.
Mar. 2	109	2096	40	970
Mar. 4	171	3416	77	1704
Mar. 6	129	2738	51	1165
Mar. 9	156	3495	77	1802
Mar. 14	239	4985	135	3090
Mar. 16	276	5465	148	3205
Mar. 18	324	6576	223	5390
Mar. 19	480	9915	304	6800
Mar. 21	622	12100	444	9295
Mar. 22	317	6035	183	3960
Mar. 23	511	9716	336	7299
Mar. 24	329	6490	203	4175
Mar. 25	359	6750	279	5920
Mar. 28	328	5595	244	5115
Mar. 27	399	7870	283	6310
Mar. 28	309	5390	195	4140
Mar. 29	371	6765	251	5325
Apr. 1	344	6830	261	6545

season than did the pistillate and that this difference was proportionally greater during the fore part of the cutting season than during the latter part. All staminate rows except No. 51 produced a greater weight of spears than their corresponding pistillate rows. This exception can be easily explained, however, from the small average size of the crowns used in planting row 51, as compared with 52. The spears of the staminate plants were smaller on the average than those from the pistillate plants, but out-yielded the latter by 35 per cent.

The total number and weight of spears cut from all staminate and pistillate plants each harvest day in 1925 are given in table 7.

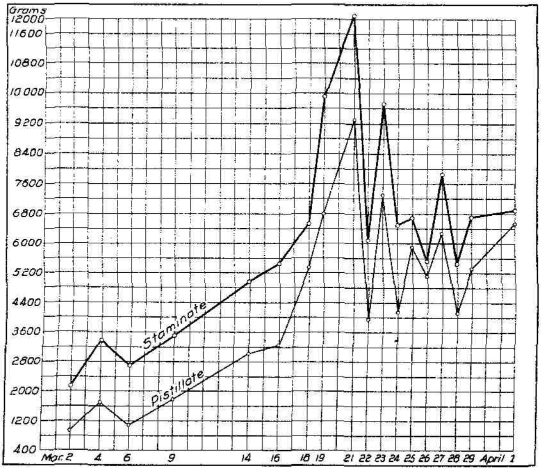


Fig. 6.—Comparison of the total yield of spears from 1949 staminate plants, and 1922 pistillate plants, on different days during first cutting season.

It is seen from the accompanying table and graph (fig. 6) that on no day during the first season of cutting did the number and weight of spears harvested from pistillate plants equal the number and weight of spears from staminate plants. While there are twenty-seven more staminate than pistillate plants, this difference is not significant in such a large population.

SUMMARY

Asparagus officinalis is normally dioecious. All asparagus flowers are apparently potentially hermaphrodite. During floral development there is, except in rare cases, an abortion of one set of sex organs. The following flower forms occur: Strongly pistillate, weakly pistillate, hermaphrodite, weakly staminate, and strongly staminate.

In a large population there are approximately equal numbers of staminate and pistillate plants.

Asparagus has certain secondary sex characters:

(*a*) Staminate plants have a tendency to express their sex earlier in the life of the individual than do pistillate plants.

(*b*) The average height of the first flower-bearing shoot of staminate plants is exceeded by that of the first flower-bearing shoot of pistillate plants.

(*c*) During both the first and second seasons of growth from the transplanting of the crown, staminate plants produce a greater number of stalks on each crown than do pistillate. The difference between staminate and pistillate plants in the green weight of tops is not significant when the berries are included, but if the weight of the green tissue alone is considered, the total weight of the tops of staminate plants is considerably greater than that of pistillate. It appears that the food manufacturing surface of staminate plants exceeds that of the pistillate.

(*d*) During the first harvest season, the staminate plants out yield the pistillate throughout the entire cutting period, but the difference is greatest during the early part of the season.

(*e*) During the first harvest season, the average number and weight of spears from a crown are greater from staminate than from pistillate plants, but the average weight of the individual spears from pistillate plants exceeds that from staminate.

LITERATURE CITED

[1] COULTER, J. M., BARNES, C. R., and COWLES, H. C.
1911. A Textbook of Botany, **2**:485–964.

[2] GREEN, W. J.
1890. Asparagus. Ohio Agr. Exp. Sta. Bul. 9, 2nd Ser., **3**:241–244.

[3] GUINIER, P.
1921. Variation in sexuality, dioecism and sexual dimorphism of *Pinus montana* and *P. sylvestris*. Comp. Rend. Seances Soc. Biol. **84**:94–96.

[4] MCPHEE, HUGH C.
1924. The influence of environment on sex in hemp, *Cannabis sativa* L. Jour. Agr. Res. **28**:1067–1080.

[5] NORTON, J. B.
1913. Methods used in breeding asparagus for rust resistance. U. S. Dept. Agr., Bureau Plant Industry, Bul. **263**:1–60.

[6] ROSA, J. T.
1925. Sex expression in asparagus. Hilgardia 1 (no. 12). (*In press.*)

[7] TOMPSON, H. F.
1923. Asparagus notes. Market Growers Jour. **32**:92.

[8] TIEDJENS, VICTOR A.
1924. Some physiological aspects of Asparagus officinalis. Proc. Amer. Soc. Hortic. Sci. **21**:129–140.

[9] YAMPOLSKY, CECIL.
1920. The occurrence and inheritance of sex intergradations in plants. Amer. Jour. Bot. **7**:21–38.